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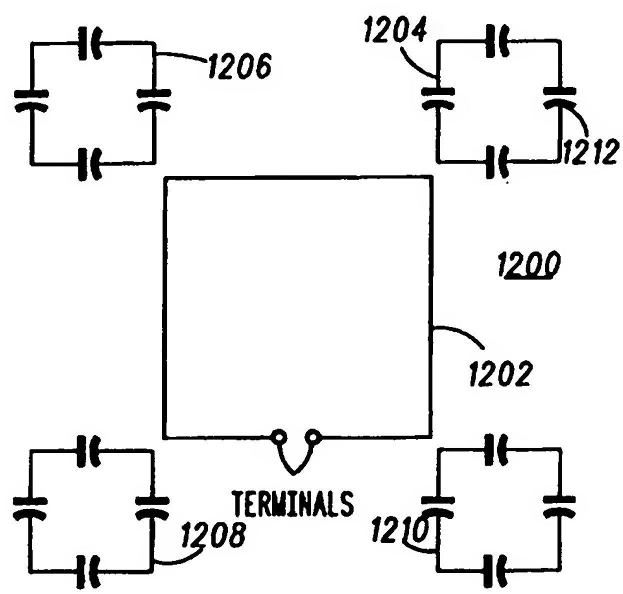
(54) Title: MAGNETIC FIELD ANTENNA AND METHOD FOR FIELD CANCELLATION

(57) Abstract

The present invention provides a magnetic field antenna (1200) and method for utilizing a central loop (1202), carrying a current produced by a signal source or induction by an external field and a plurality of at least three non-collinear peripheral loops (1204, 1206, 1208, 1210), distributed along a perimeter of the central loop (1202), arranged for substantially cancelling a moment of the central loop (1202), and where transmitting, minimizing radiation, and where receiving, for minimizing a current induced by a substantially uniform field.



MAGNETIC FIELD ANTENNA AND METHOD FOR FIELD CANCELLATION

Field of the Invention

The present invention relates generally to RF identification systems and, in particular, to inductively-coupled magnetic loop antenna systems.

Background of the Invention

RF identification (RF ID) systems are known to comprise a plurality of RF ID tags or cards that interact with one or more reader/writer terminals or devices. A reader/writer terminal couples both power and data signals to the RF tag circuit, but only when the tag is in the vicinity of the terminal. Once the RF tag circuit couples enough energy to power up the main circuit, the RF tag will conduct a transaction with the reader/writer terminal. Transaction types vary from simple identification to financial applications. In order for an RF ID system to operate properly, it is critical that the terminal and tag have a reliable and efficient channel of communication. It is very important to understand the coupling mechanisms between the tag antenna(s) and the terminal antenna(s).

Several different approaches to antenna design have been previously investigated. In general, an RF ID antenna system can be classified as either electro-static or magneto-static, depending on the dominant method of coupling. An electro-static system relies on capacitive coupling of the power and data signals between the tag and terminal, while a magneto-static system relies on inductive coupling. Electro-static and magneto-static systems are also referred to as "close-coupled" and "remote-coupled" systems, respectively. Electro-static systems typically require that the tag make or nearly make physical,

but not electrical, contact with the terminal. Magneto-static systems are not nearly as limited. The precise coupling region, within which a transaction between tag and terminal can occur, is governed by several factors, including the power available from the terminal, the power required by the tag circuit, and the level of interference present in the environment.

A magneto-static system is relatively easy to understand, since it is essentially a system of mutually coupled inductors. The key to an efficient system is designing a system of antennas capable of operating within a specified coupling region, but which are inoperable outside of this region. Thus it is necessary to design an antenna with a limited operating range. This is important since there could be several terminals at a transaction center which gives rise to concern about interference. There are also regulatory specifications which limit the maximum allowable level of radiation. Again, a coil which minimizes excess radiation would be quite feasible. One last important aspect of a limited coupling region is security, particularly for financial transactions. It would be highly beneficial to limit the spatial extent through which sensitive information is broadcast.

Thus, there is a need for a magnetic field antenna with a set of loops and method for substantially canceling a moment of a central loop, and where transmitting, minimizing radiation, and where receiving, for minimizing a current induced by a substantially uniform field.

Brief Description of the Drawings

FIG. 1 is a schematic representation of one embodiment of a moment canceling antenna arranged in accordance with the present invention.

FIG. 2 is a schematic representation of another embodiment of a moment canceling antenna including a collocated antenna which provides maximum isolation in accordance with the present invention.

FIG. 3 is a diagram of the method of substantial moment cancellation for a single antenna system in accordance with the present invention.

FIG. 4 is a diagram of the method of substantial moment cancellation and maximum isolation for a dual antenna system in accordance with the present invention.

FIG. 5 is a schematic representation of a specific embodiment of a moment canceling antenna arranged in accordance with the present invention.

FIG. 6 is a schematic representation of a specific embodiment of a moment canceling antenna, with balanced flux, including a collocated antenna which provides maximum isolation in accordance with the present invention.

FIG. 7 is a schematic representation of another specific embodiment of a moment canceling antenna, with a slight flux imbalance, including a collocated antenna which provides maximum isolation in accordance with the present invention.

FIG. 8 is a schematic representation of a particular embodiment which contains a square central loop, square peripheral loops located internal to the central loop at its vertices, and a square collocated loop located concentric to the central loop with its vertices bound by the interior of the peripheral loops.

FIG. 9 is a schematic representation of a particular embodiment which contains a square central loop, square peripheral loops located internal to the central loop at its vertices, and a square collocated loop

located concentric to the central loop with its vertices exterior to the central loop.

FIG. 10 is a schematic representation of a particular embodiment which contains a square central loop, square peripheral loops located external to the central loop connected by extensions from the vertices along the central loops diagonals, and a square collocated loop located concentric to the central loop with its vertices contained on the extensions.

FIG. 11 is a schematic representation of a particular embodiment which contains a square central loop, square peripheral loops located external to the central loop at its vertices, and a polygonal collocated loop located concentric to the central loop which follows the perimeter of the combination of central and peripheral loops.

FIG. 12 is a schematic representation of a particular embodiment which contains a square central loop and square peripheral loops located externally at its vertices which are magnetically coupled to the central loop and contain distributed capacitive elements.

FIG. 13 is a schematic representation of a coupling pattern for a square loop which indicates a normalized mutual inductance.

FIG. 14 is a schematic representation of a coupling pattern showing the magnitude for the mutual inductance for the loop geometry of FIG. 5.

FIG. 15 is a schematic representation of a coupling pattern showing both the magnitude and phase for the mutual inductance for the loop geometry of FIG. 5.

FIG. 16 is a schmatic representation of isolation data for the two-inductor system of FIG. 6.

Detailed Description of a Preferred Embodiment

One embodiment of the magnetic field antenna is illustrated in FIG. 1, which includes a central conducting loop and a plurality of at least three non-collinear peripheral conducting loops distributed along a perimeter of the central loop. The peripheral loops are arranged such that there is substantial cancellation of the moment of the central loop. The antenna current is either generated by a signal source or induced by an external field. This current represents either a power signal, a data signal, or a combination of power and data signals. When transmitting, the magnetic fields, particularly the intermediate and far-field components, produced by this antenna are minimized. When receiving, this antenna minimizes current induced by a substantially uniform field, as could be caused by background interference. In this context, a substantially uniform field refers to one that is uniform over the volume of the antenna. The conductors used to construct the antenna could include wires, printed circuit board traces, or conductive ink patterns.

Another embodiment of the magnetic field antenna is illustrated in FIG. 2, which includes the antenna from FIG. 1 as well as a second collocated loop antenna. The function of the second antenna is to transmit/receive data and/or provide power to an external RF receiver/transmitter.

The loops used in the magnetic field antennas of FIG. 1 and FIG. 2 are in the shape of N-sided polygons or closed three-dimensional contours. This includes the central and peripheral loops of the antenna in FIG. 1 as well as the collocated loop in FIG. 2. For the magnetic field antenna of FIG. 1, the peripheral loops are attached to the central loop by a direct electrical connection, a three-dimensional extension, or indirectly via magnetic coupling. A direct connection is established by breaking the central loop and inserting a peripheral loop at the break

point. An extension is established similar to a direct connection, except that an additional pair of conductors is used to offset the position of a peripheral loop relative to the break point in the central loop. If a peripheral loop is not electrically connected to the central loop by a direct connection or an extension, then the only connection is via magnetic field coupling. The positions of the breakpoints, and the length and orientation of the extensions are arbitrary. Also, the central and peripheral loops of FIG. 1 and the collocated loop of FIG. 2 each contain a predetermined number of turns, wherein each loop may have a different number of turns. Additionally, the central and peripheral loops of FIG. 1 and the collocated loop of FIG. 2 each contain a predetermined distribution of series/parallel circuit elements/networks, including inductors, capacitors, resistors, short circuits, open circuits, and active devices. This predetermined distribution of circuit elements/networks may be different for each loop.

A method for providing substantial moment cancellation for a magnetic field antenna is illustrated in FIG. 3. This method contains the embodiment of FIG. 1. A current is provided to the central loop of this antenna. Simultaneously, this same current is provided to the plurality of at least three non-collinear peripheral loops distributed along a perimeter of the central loop , as shown in FIG. 1. This current is either generated by a signal source or induced by an external field, and it represents either a power signal, a data signal, or a combination of power and data signals. For a substantially balanced-moment antenna, it is necessary to design the central and peripheral loops such that the central moment is substantially canceled by the net peripheral moment. The moment is calculated as the product of the number of turns in a loop, the loop current, and the loop area. This assumes that the turns are essentially overlapping, as could be done with insulated wire conductors. On the other hand, if the conductors are printed circuit board traces, it is necessary to use spiral loops to achieve more turns. For this topology, the moment is calculated as the sum of the moments for each turn in the spiral loop. Under these conditions, the magnetic

field antenna of FIG. 1 provides a substantially canceled net magnetic moment. This results in minimal radiation when transmitting, and minimal induced current from substantially uniform fields when receiving.

A method for providing substantial moment cancellation and maximum isolation between antennas for a magnetic field antenna is illustrated in FIG. 4. This method contains the embodiment of FIG. 2. The primary antenna is that of FIG. 1, which is the combination of the central and plurality of at least three non-collinear peripheral loops distributed along a perimeter of the central loop. The secondary antenna is the collocated loop. The primary antenna operates precisely as described in the previous method. A current, different from that in the primary antenna, is provided to the secondary antenna. This current is either generated by a signal source or induced by an external field, and it represents either a power signal, a data signal, or a combination of power and data signals. The primary antenna is designed for substantial moment cancellation as described in the previous method. The secondary antenna is designed with a specific shape to provide maximum isolation with respect to the primary antenna. The shape is a function of the primary antenna topology. Specific dimensions are readily calculated via numerical simulation of the magneto-static or quasi-magneto-static fields.

A specific magnetic field antenna is illustrated in FIG. 5. The central and peripheral loops are single-turn squares. The four peripheral squares are attached to the central square and its vertices. Also, the peripheral squares are half-scaled versions of the central square. Clearly the net peripheral moment has an equal magnitude to the central moment. Due to the opposite direction of current flow in the peripheral coils relative to the central coil, the two moments are 180° out of phase. This condition produces optimal moment cancellation.

A specific magnetic field antenna system is illustrated in FIG. 6. It includes the antenna from FIG. 5, as well as a collocated square loop

which is coplanar and concentric with the other antenna. The dimensions of the collocated square loop are optimized via numerical simulation so that there is no coupling to the other antenna, thus providing maximum isolation. For this configuration, there is an optimum dimension of the collocated square loop such that its vertices lie within the perimeter of the peripheral square loops of the other antenna.

Another specific magnetic field antenna system is illustrated in FIG. 7. It includes an antenna similar to that in FIG. 5, except that peripheral loops are modified such that there is a slight moment imbalance. There is also a collocated square loop which is coplanar and concentric with the other antenna. The dimensions of the collocated square loop are optimized via numerical simulation so that there is no coupling to the other antenna, thus providing maximum isolation. For this configuration, there is an optimum dimension of the collocated square loop such that its vertices lie outside the perimeter of the other antenna, thus requiring that it circumscribes this other antenna.

FIG. 8 is a schematic representation of an example configuration in accordance with the present invention. The central, peripheral, and collocated loops are all square in shape. The peripheral loops are directly connected to the central loop, located in its interior. The collocated loop partially overlaps the peripheral loops to increase isolation. FIG. 9 is a similar geometry except that the collocated loop circumscribes the combination of central and peripheral loops to maximize isolation. Note that the peripheral loops are connected as illustrated in FIG. 5, such that their moments oppose the central moment.

FIG. 10 is a schematic representation of an example configuration in accordance with the present invention. Again, the central, peripheral, and collocated loops are all square in shape. The peripheral loops are exterior to the central loop and connected at the its vertices via extensions, which are in this case planar. The collocated loop is

concentric with the central loop. Its size could be adjusted to change the self-inductance as well as its mutual inductance to the combination of central and peripheral coils. Note that the peripheral loops are connected as illustrated in FIG. 5, such that their moments oppose the central moment.

FIG. 11 is a schematic representation of an example configuration in accordance with the present invention. The central and peripheral loops are square in shape. The peripheral loops are exterior to the central loop and are connected directly at the vertices of the central loop. The collocated loop is a polygonal shape which follows the perimeter of the combination of the central and peripheral loops. This configuration also yields high isolation. Note that the peripheral loops are connected as illustrated in FIG. 5, such that their moments oppose the central moment.

FIG. 12 is a schematic representation of an example configuration in accordance with the present invention. The central (1202) and peripheral loops (1204, 1206, 1208, 1210) are all square in shape. The peripheral loops are centered along the exterior diagonals of the center loop. There is no direct electrical connection present, rather they are connected via magnetic field coupling. In addition, there are capacitors (1212) distributed along each edge of each of the peripheral loops. The capacitive loading can be used to alter the loop impedance, thus changing the magnitude of the induced currents in the peripheral loops.

For FIGs. 13-15 a small square loop inductor is used as a probe for performing the mutual inductance calculations via magneto-static simulation.

FIG. 13, numeral 1300, is a schematic representation of a coupling pattern for a square loop which indicates a normalized mutual inductance. The single square loop geometry produces a central peak

(1302) in the coupling pattern which is confined within the perimeter of the loop.

FIG. 14, numeral 1400, is a schematic representation of a coupling pattern showing the magnitude for the mutual inductance for the loop geometry of FIG. 5. There is central peak (1402) that corresponds to the central peak (1302) of FIG. 13 that is due to the central square loop. In addition, there are four smaller outlying peaks (1404, 1406, 1408, 1410) produced by the peripheral loops. The radiation corresponding to the outlying peaks (1504, 1506, 1508, 1510) substantially cancels the radiation corresponding to the central peak (1502). FIG. 15, numeral 1500, is a schematic representation of a coupling pattern showing both the magnitude and phase for the mutual inductance for the loop geometry of FIG. 5. FIG. 15 is identical to FIG. 14 except that the outlying peaks are inverted , which is indicative of the 180° phase shift between the central and peripheral loop currents.

FIG. 16, numeral 1600, is a schematic representation of isolation data for the two- inductor system of FIG. 6. Mutual inductance is shown on the y-axis, and the x-axis is an edge length of a square, co-located concentric loop. The first peak (1602) occurs when the co-located loop (a second inductor) overlaps the central loop of the combination of central and peripheral loops of the first inductor. The second peak (1604) occurs when the co-located loop partially overlaps the outermost edges of the peripheral loops. The coupling null (1606) occurs for a square co-located loop whose vertices lie within the peripheral loops, thus occurring between the first and second peaks.

The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

We claim:

1. A magnetic field antenna having a conductor comprising:

A) a central loop, carrying a current produced by one of:

A1) a signal source; and

A2) induction by an external field;

and

B) a plurality of at least three non-collinear peripheral loops, distributed along a perimeter of the central loop, arranged for substantially canceling a moment of the central loop, and

where transmitting, minimizing radiation, and

where receiving, for minimizing a current induced by a substantially uniform field.

2. A method for providing substantial moment cancellation for a magnetic field antenna comprising the steps of :

A) providing, along a conductor arranged in a central loop, a current produced by one of:

A1) a signal source; and

A2) induction by an external field;

and

B) simultaneously providing the current to a plurality of at least three non-collinear peripheral loops that are distributed along a perimeter of the central loop and arranged for substantially canceling a moment of the central loop, and

where transmitting, minimizing radiation, and

where receiving, for minimizing a current induced by a substantially uniform field.

3. A method for providing substantial moment cancellation and maximum isolation between antennas for a magnetic field antenna comprising the steps of :

A) providing, along a conductor arranged in a central loop, a first current produced by one of:

A1) a signal source; and

A2) induction by an external field;

and

B) simultaneously providing the first current to a plurality of at least three non-collinear peripheral loops that are distributed along a perimeter of the central loop and arranged for substantially canceling a moment of the central loop, and

where transmitting, minimizing radiation, and

where receiving, for minimizing a current induced by a substantially uniform field,

and further utilizing a co- located loop antenna that has a second current, wherein the collocated loop antenna has predetermined dimensions with respect to a combination of the central loop and the non-collinear peripheral loops and where the first current represents at least one of power and data signals, the second current represents at least one of data and power signals.

4. A magnetic field antenna having a conductor comprising:

A) a central rectangular/square loop, carrying a current produced by one of:

A1) a signal source; and

A2) induction by an external field;

and

B) a plurality of four peripheral rectangular/square loops, distributed at each corner of the central rectangular/square loop and located internally/externally to the central rectangular/square loop, arranged for substantially canceling a moment of the central rectangular/square loop, and

where transmitting, minimizing radiation, and

where receiving, for minimizing a current induced by a substantially uniform field.

5. A magnetic field antenna having a conductor comprising:

A) a central rectangular/square loop, carrying a current produced by one of:

A1) a signal source; and

A2) induction by an external field;

and

B) a plurality of four peripheral rectangular/square loops, distributed at each corner of the central rectangular/square loop and located internally/externally to the central rectangular/square loop, arranged for substantially canceling a moment of the central rectangular/square loop, and

where transmitting, minimizing radiation, and

where receiving, for minimizing a current induced by a substantially uniform field,

and further including:

C) a rectangular/square collocated loop having a predetermined dimension that provides maximum isolation with respect to a combination of the central rectangular/square loop and the plurality of four peripheral rectangular/square loops.

6. A radio frequency identification reader/writer terminal having a magnetic field antenna with a conductor comprising:

A) a central loop, carrying a current produced by one of:

A1) a signal source; and

A2) induction by an external field;

and

B) a plurality of at least three non-collinear peripheral loops, distributed along a perimeter of the central loop, arranged for substantially canceling a moment of the central loop, and

where transmitting, minimizing radiation, and

where receiving, for minimizing a current induced by a substantially uniform field.

7. A radio frequency identification/transaction tag having a magnetic field antenna with a conductor comprising:

A) a central loop, carrying a current produced by one of:

A1) a signal source; and

A2) induction by an external field;

and

B) a plurality of at least three non-collinear peripheral loops, distributed along a perimeter of the central loop, arranged for substantially canceling a moment of the central loop, and

where transmitting, minimizing radiation, and

where receiving, for minimizing a current induced by a substantially uniform field.

8. The radio frequency identification/transaction tag of claim 48 wherein the shape of the collocated loop antenna is one of:

A) an N-sided polygon, where N is a predetermined integer; and

B) a predetermined closed contour in three-dimensional space.

9. The radio frequency identification/transaction tag of claim 48 wherein the shape of the central loop is one of:

A) an N-sided polygon, where N is a predetermined integer wherein the peripheral loops are connected to the central loop at predetermined points by one of:

direct electrical connection; and

extensions in three-dimensional space; and

magnetic coupling;

and

B) a predetermined closed contour in three-dimensional space wherein the peripheral loops are connected at predetermined points to the central loop by one of:

direct electrical connection; and

extensions in three-dimensional space; and

magnetic coupling.

10. The radio frequency identification/transaction tag of claim 48 wherein the shapes of each of the unique peripheral loops are one of:

A) an N-sided polygon, where N is a predetermined integer, that is connected to the central loop at a predetermined point by one of:

direct electrical connection; and

extensions in three-dimensional space; and
magnetic coupling;

and

B) a predetermined closed contour in three-dimensional space connected to the central loop at a predetermined point by one of:

direct electrical connection; and
extensions in three-dimensional space; and
magnetic coupling.

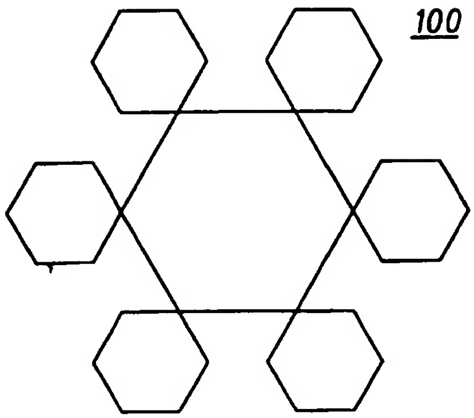


FIG.1

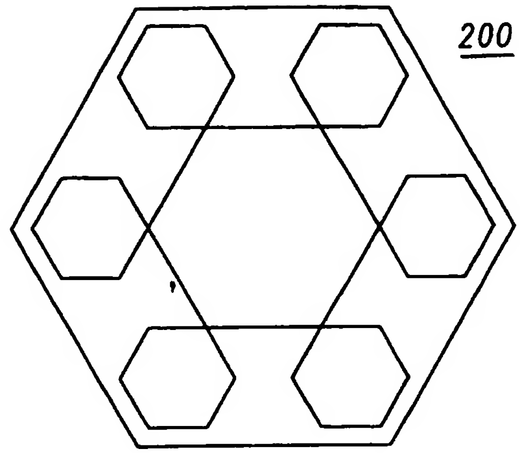
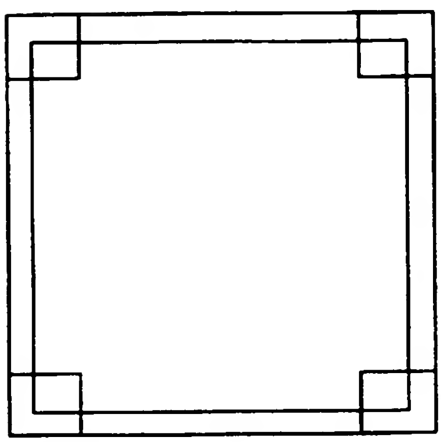
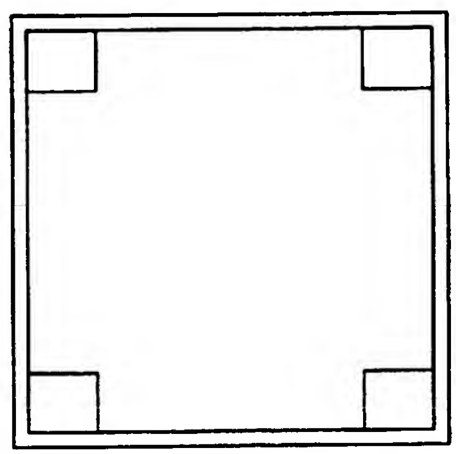


FIG.2



800 FIG.8



900 FIG.9

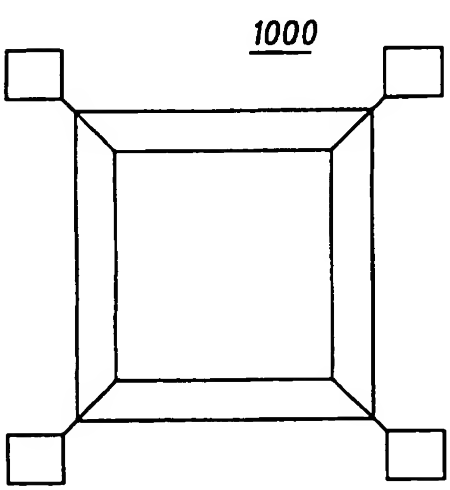


FIG.10

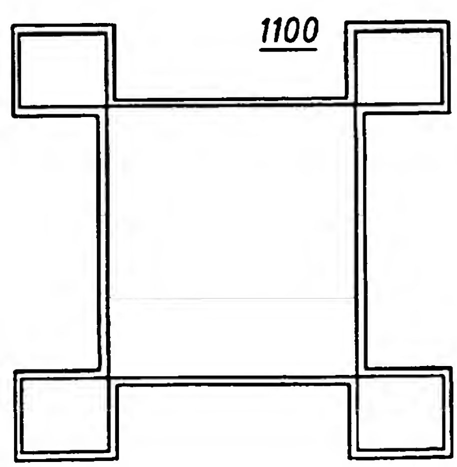


FIG.11

300

302

PROVIDING, ALONG A CONDUCTOR ARRANGED IN A CENTRAL LOOP, A CURRENT PRODUCED BY ONE OF:
A1) A SIGNAL SOURCE;AND
A2) INDUCTION BY AN EXTERNAL FIELD

304

SIMULTANEOUSLY PROVIDING THE CURRENT TO A PLURALITY OF AT LEAST THREE NON-COLLINEAR PERIPHERAL LOOPS THAT ARE DISTRIBUTED ALONG A PERIMETER OF THE CENTRAL LOOP AND ARRANGED FOR SUBSTANTIALLY CANCELING A MOMENT OF THE CENTRAL LOOP, AND

WHERE TRANSMITTING, MINIMIZING RADIATION, AND
WHERE RECEIVING, FOR MINIMIZING A CURRENT INDUCED

BY A SUBSTANTIALLY UNIFORM FIELD

FIG.3

400

402

PROVIDING, ALONG A CONDUCTOR ARRANGED IN A CENTRAL LOOP, A FIRST CURRENT PRODUCED BY ONE OF:
A1) A SIGNAL SOURCE;AND
A2) INDUCTION BY AN EXTERNAL FIELD

404

SIMULTANEOUSLY PROVIDING THE FIRST CURRENT TO A PLURALITY OF AT LEAST THREE NON-COLLINEAR PERIPHERAL LOOPS THAT ARE DISTRIBUTED ALONG A PERIMETER OF THE CENTRAL LOOP AND ARRANGED FOR SUBSTANT-IALLY CANCELING A MOMENT OF THE CENTRAL LOOP, AND

WHERE TRANSMITTING, MINIMIZING RADIATION, AND
WHERE RECEIVING, FOR MINIMIZING A CURRENT INDUCED
BY A SUBSTANTIALLY UNIFORM FIELD

AND FURTHER UTILIZING A COLLOCATED LOOP ANTENNA THAT HAS A SECOND CURRENT, WHEREIN THE COLLOCATED LOOP ANTENNA HAS PREDETERMINED DIMENSIONS WITH RESPECT TO A COMBINATION OF THE CENTRAL LOOP AND THE NON-COLLINEAR PERIPHERAL LOOPS AND WHEREIN,

WHERE THE FIRST CURRENT REPRESENTS AT LEAST ONE OF POWER AND DATA SIGNALS, THE SECOND CURRENT REPRESENTS AT LEAST ONE OF THE DATA AND POWER SIGNALS

FIG.4

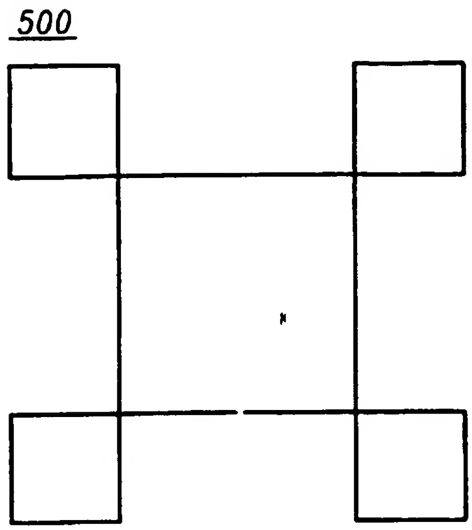


FIG.5

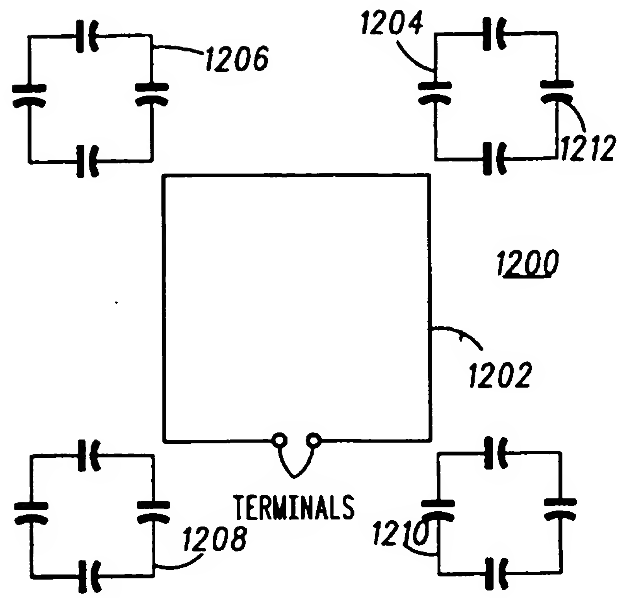


FIG.12

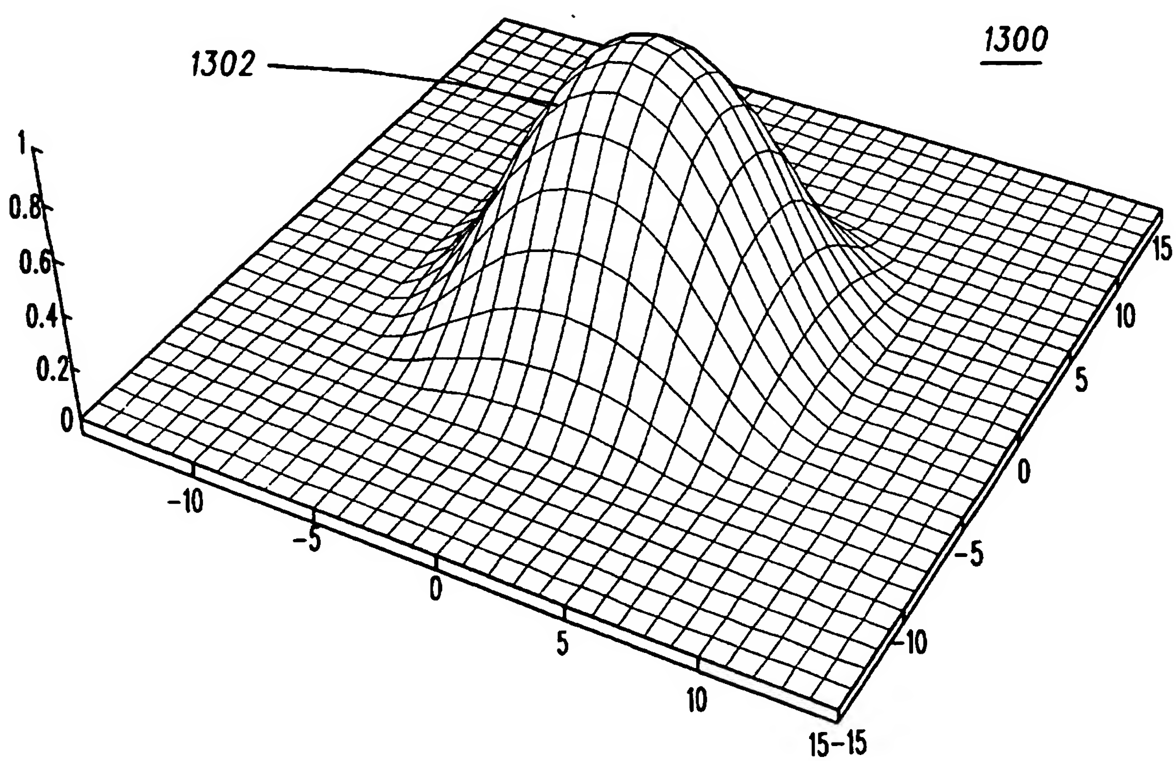


FIG.13

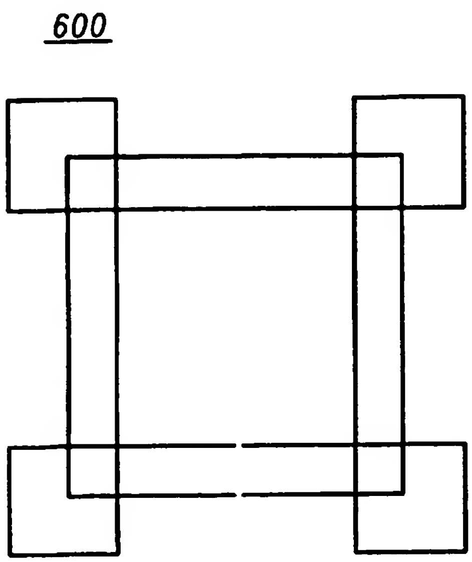


FIG.6

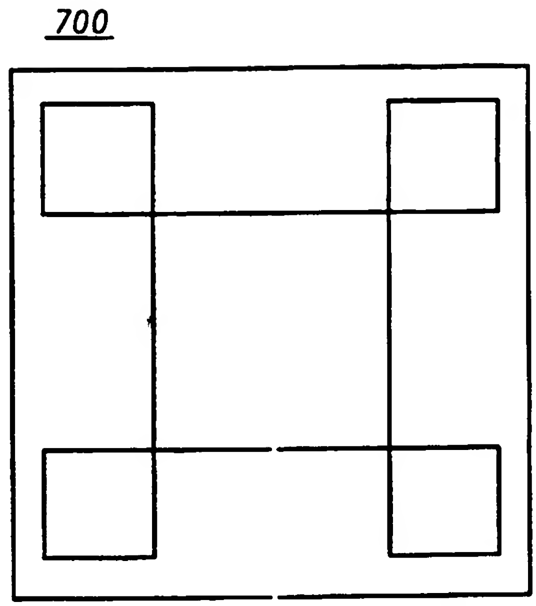


FIG.7

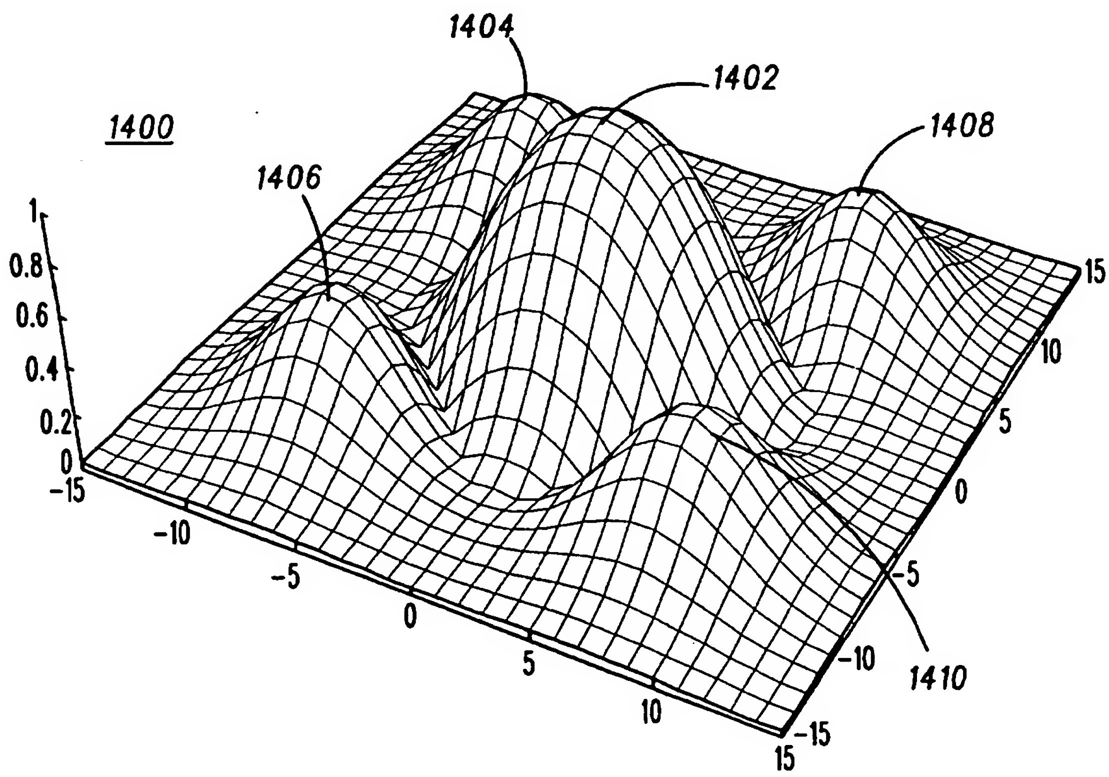


FIG.14

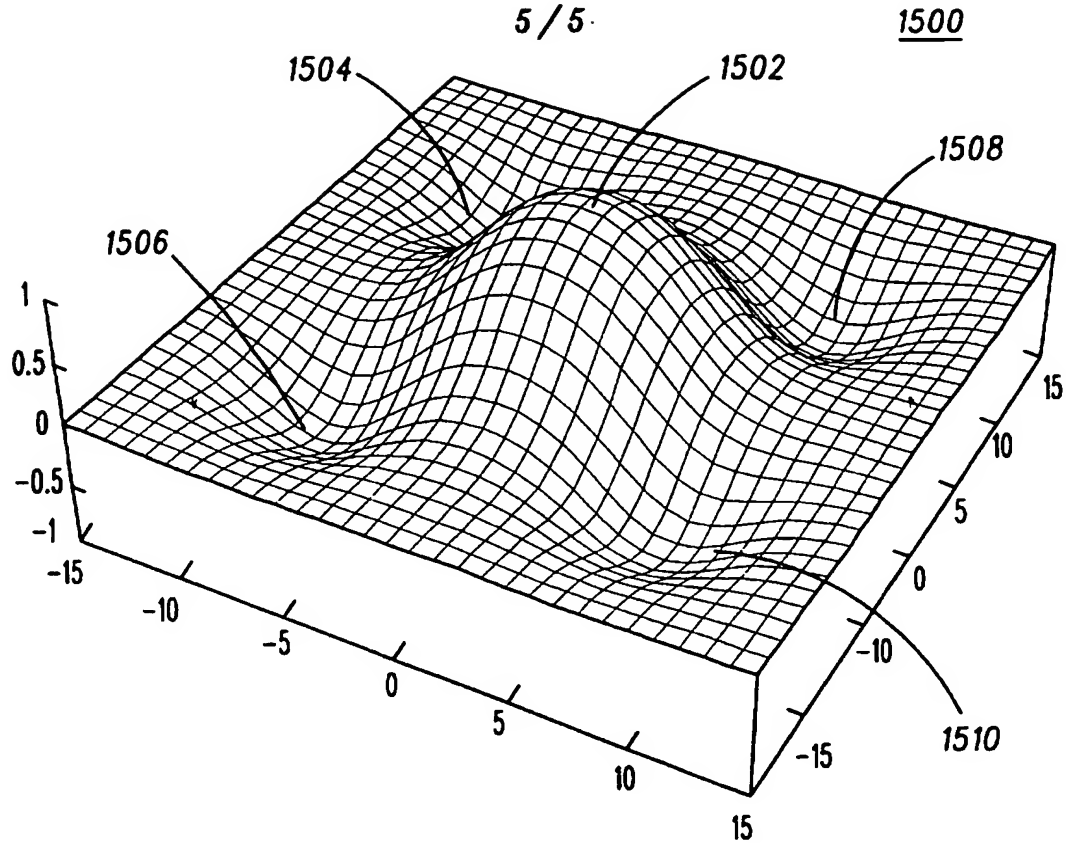

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FIG.15

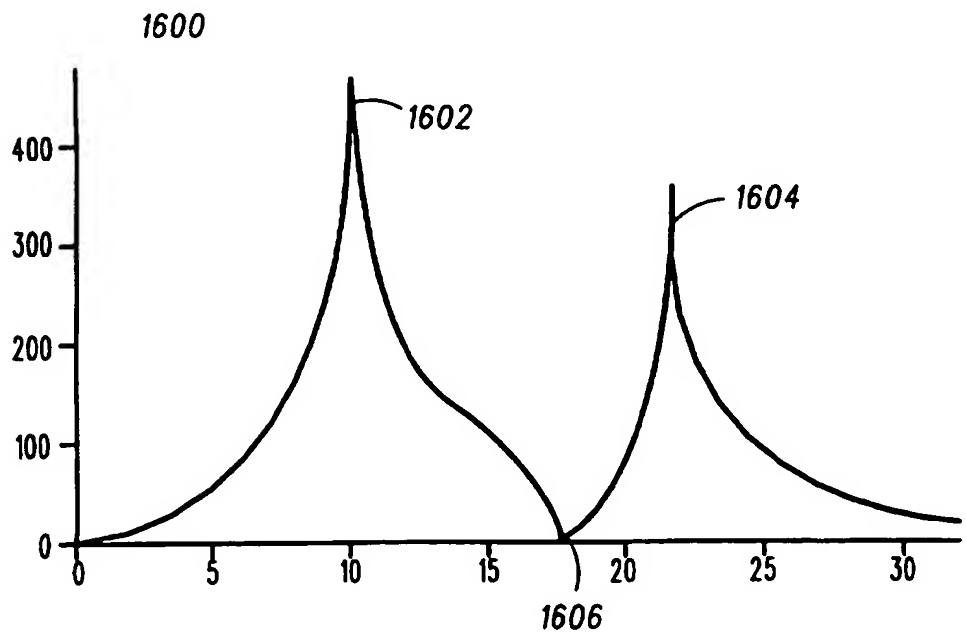
1600
1602
1604
1606
400
300
200
100
0
5
10
15
20
25
30

FIG.16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/13240

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H01Q 1/38, 7/00
US CL :343/742,867
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 343/742,867

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 2,596,595 A (POSTHUMUS) 13 MAY 1952 (13/05/52), see Figure 2 and column 3, lines 3-26.	1,2 ---- 3,5-7
Y	US 3,683,389 A (HOLLIS) 08 AUGUST 1972 (08/08/72), see Figure 2 and column 3, lines 27-40.	3,5
Y	US 4,864,292 A (NIEUWKOOP) 05 SEPTEMBER 1989 (05/09/89), see Figures 1 and 7.	6,7
Y	US 5,142,292 A (CHANG) 25 AUGUST 1992 (25/08/92), see Figure 1.	6,7

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"B" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 OCTOBER 1997	32.10.97

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	MICHAEL WIMER
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/13240

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 8-10
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

these claims are dependent upon claim 48 which is not in this case.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.